NBSIR 73-217

Use of Computer Networks in Support of Interactive Graphics for Computer-Aided Design and Engineering

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30 June 1972

Interim Report

Prepared for
Contract No. 72-90013
U.S. Army Electronics Command
Fort Monmouth, N. J. 07703

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U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary

NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

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1. INTRODUCTION

1.1 Background

The material presented in this report is a result of work performed between 1 July 1971 and 30 June 1972 as part of a long-term "Interactive Computer-Aided Techniques Study" initiated in August 1970. This long-term effort of research, development and consultation by the National Bureau of Standards is in direct support of the Department of the Army Program of Research and Development in Computer and Information Sciences and the program in Computer Aided Design and Engineering.

The intent of this cooperative arrangement between NBS and the U.S. Army, specifically the U.S. Army Electronics Command (ECOM), Ft. Monmouth, N.J., is to provide both general and specific assistance to ECOM in the initiation of the use of interactive graphics as a new and important tool in computer-aided design and engineering.

From year to year NBS and ECOM select the topics for that year's activity based on the outline for the long-term effort, taking into account current emphases of related programs at ECOM and NBS. In general, appropriate NBS staff are available on a continuing basis to consult to ECOM and its parent organization, the Army Materiel Command, in the methods of application of interactive computer-aided techniques to meet Army requirements for research, development, and engineering. This consulting activity takes advantage of NBS experience in

the areas of hardware, software, overall systems planning, and general applications support.

Other pursuits from which specific activities can be selected include: the performance of research and development necessary to identify and test measures of adequacy, suitability and performance of interactive computer-aided techniques; the development and transfer to usable formats of computer software which supports interactive CAD-E systems; the documentation, dissemination and general support of government sponsored software for interactive graphics; and the performance of exploratory studies involving the application of devices such as flying spot optical scanners and graphical displays to problems in interactive generation, maintenance, and updating of computer based engineering documentation.

This work is being conducted within the Institute for Computer Sciences and Technology of the National Bureau of Standards. Specifically, it is being performed within the framework of a principal objective of this Institute: to provide technical advisory and consultative services to other government agencies as required to assist them in making effective and efficient use of computer-based systems. The technical area covered by this project, interactive graphics, and also the use of computer networks in support of interactive graphics, is a new type of application of computer systems that supports flexible conversational interaction between user and computer. Development and application of this type of inter-

active computer system is of particular importance within the teleprocessing program of the NBS Institute for Computer Sciences and Technology.

1.2 Scope of Project Activity

The primary emphasis during this project period has been on investigating the feasibility of using computer networks to support interactive graphics for computer-aided design and engineering, utilizing design terminals in a laboratory environment. Altenative means for providing remote computing service in support of interactive graphics have been studied and the project has taken full advantage of the location of a node of the experimental ARPA Computer Network at the National Bureau of Standards. This node has been used to set up a test bed configuration in support of the interactive graphics facilities at ECOM.

In the course of this project, several practical networking problems were identified and are discussed in this report. Some interim solutions were found; a more comprehensive approach to the general problem may be expected to emerge from continued system development. System reliability can be expected to increase as the ARPA Network and its hosts evolve toward greater stability.

Also during this period a variety of consulting services have been provided. These have included continual interaction with ECOM during their implementation of an interactive

graphics laboratory. During several meetings attended by ECOM and NBS personnel numerous ideas concerning the state-of-the-art of interactive graphics and related technologies were discussed. NBS staff members are maintaining close observation of other potentially related interactive graphics efforts in the United States and elsewhere, especially those in university environments, from which developments useful to ECOM in its implementation of the "design terminal concept" may be extracted. Discussion of these observations has taken place during the mutual visits by NBS and ECOM personnel. Also, during the year extensive NBS experience in computer networking has been made available both to ECOM and to its parent command, the Army Materiel Command. In addition to informal discussions with ECOM personnel, a formal presentation was made to the AMC CAD-E council on 29 September 1971 concerning the ARPA Network and its potential use by AMC in support of its CAD-E program.

1.3 Relation to Other Current and Planned Activity

The tasks conducted within this project during the period covered by this report have been accompanied by other intensive related activity at NBS. The work most closely related to this project has been in the general area of performance measurement of interactive remote access computer systems. In that area, emphasis has been on determining criteria and developing and testing tools for measuring the performance of computer systems as viewed by a typical interact-

ive user at a remote access terminal.[1] Specific effort has been devoted to two types of tools. One is the ICST "Dialogue Monitor" that collects basic data about system performance, user behavior, and communication line utilization. The second is a "Terminal Environment Simulator" which will permit measurement of performance of remote access systems under controlled conditions.

The techniques being developed in this performance measurement program should be directly applicable to the performance measurement problems associated with interactive graphics usage.[2] As discussed in the conclusions and plans section of this report, these performance measurement techniques will be applied during FY 73, along with intensive study of the development of meaningful performance criteria and measurement techniques for interactive graphics and general graphics system configurations. Experience gained in other projects within NBS in the design and implementation of dialog monitors, dialog monitor analysis routines, and general studies of interactive dialog monitoring and data interpretation are expected to be quite useful during the next project period.

During the next project period, the planned effort in support of ECOM will be concerned not only with providing network access and remote computer services in support of graphics, but will follow up studies that were begun last

year in support of ECOM in the area of performance criteria and performance measures.

1.4 Guide to this Report

In part two of this report the test bed network configuration developed during this project period is described. The general concept of a hierarchical configuration in support of graphics in a laboratory environment is developed and a series of challenges met during the implementation process are discussed.

The next part of the report summarizes NBS experience in providing computer service to remote computer users through computer networks.

Finally, significant conclusions of FY 72 work are summarized and planned extensions of this work are presented.

NOTE: The identification of certain commercial equipment in this report is done in order to adequately identify the network components discussed herein and in no sense does it imply recommendation or endorsement by the National Bureau of Standards.

2. TEST BED NETWORK CONFIGURATION

2.1 Objective

A test bed network configuration was established during FY 1972 to provide access on an experimental basis to remote computing facilities for use in conjunction with the in-house interactive graphics facility at ECOM. The objective of this configuration was to explore the capabilities of remote facilities for supporting in-house graphics applications and to investigate the methods and problems associated with the use of networks for the support of interactive computer applications of this type.

2.2 Hierarchical Configuration

The basic configuration embodied in the implementation is that of access to a hierarchy of increasingly powerful computer systems through a network. The minicomputer-based design terminal which directly supports the designer is connected through an appropriate communication circuit to a network access computer that acts as a port to a nation-wide network containing numerous and varied computer resources. Through this network connection, access to a large computer system has been provided on which a major applications program can be executed in support of the interactive terminal user at ECOM.

Specifically, the Varian 620 computer incorporated in the graphics terminal at ECOM has been connected using a dial-up voice grade circuit to a PDP-11 minicomputer at NBS. For this 2000 bit per second communication channel, a synchronous

block oriented protocol was developed that would permit a remote job entry type of communication with the remotely accessible computer resources. This protocol is described in Appendix B.

The NBS PDP-11 was then used to interface directly through the NBS Terminal Interface message Processor (TIP) to the experimental ARPA Network. This network, sponsored by the Advanced Research Projects Agency (ARPA) of the Department of Defense has attached to it a number of large and quite flexible computer facilities. One of these, the IBM 360/91 at the University of California at Los Angeles (UCLA), was chosen to be the support computer for this implementation.

So that the planned interactive graphics activity could receive adequate support for mechanical engineering design tasks, an appropriate applications package, the NASTRAN structural engineering package, was transferred by NBS from NASA to the UCLA 360/91. With the help of the staff of that installation, this package was made operational and accessible through the entire hierarchical configuration from the ECOM design terminal.

2.3 Networking Challenges

2.3.1 Use of an Experimental Network

In the process of developing a working test bed network configuration, the ARPA Network was selected to support this experiment. It is the only general purpose, large-scale

network of its kind and also is accessible at NBS through part of the NBS program to evaluate the capabilities and limitations of this type of network. However, the nature of this developing network is such that the communications network, although operable, is not 100% reliable nor is it totally stable. Numerous problems have occurred both in the use of the communications network and in the use of three major host computer systems connected to the network in preparation of this test bed configuration.

2.3.2 The Test Bed Implementation

The initial implementation plan envisioned the utilization of a new operating system for the PDP-11 being developed at the University of Illinois. The remote job entry (RJE) protocol has, however, matured slowly in the ARPA Network. In addition, the ARPA Network Terminal System (ANTS) operating system for the PDP-11 was not successfully completed by the University of Illinois during the period for which it was planned. This software package would have permitted a relatively straightforward connection through the network from the PDP-11 at NBS to the UCLA 360/91. In its absence, it was necessary for the NBS project staff to develop a new connection mechanism through the network for support of ECOM. This interim connection was made possible through the flexibility of the ARPA Network and a number of its general capabilities for transferring programs and making host-to-host computer interconnections.

The configuration actually implemented involved the development of a special program for the PDP-11 that interacts with the Varian 620 at ECOM through an agreed-upon synchronous protocol. The PDP-11 then communicates with the TIP by simulating a human user connected at one of its terminal ports operating at 2400 bits per second. A connection is then made through the TIP to a PDP-10 computer located at Bolt, Beranek, and Newman (BBN) in Cambridge, Massachusetts, operating under the TENEX operating system. A program was developed by the NBS project staff to satisfy the "user remote job entry protocol" necessary to connect to the UCLA IBM 360/91. This PDP-10 program is a substantial revision of a program written by Eric Harslem for the PDP-10 at the RAND Corporation, Santa Monica, California. That program, designed for direct human use, did not lend itself easily to use by another machine (which might be considered as an "automaton") rather than a human user. The PDP-11, while simulating a human user, may be viewed as an automaton in that it cannot respond to exception conditions with the flexibility of a human user. The Varian 620 computer at ECOM also appears as an automaton and, therefore, depends on a well-behaved network. Similar problems of this type may arise at ECOM in the handling of output generated by the remote applications programs.

For this implementation, the NASA Stress Analysis (NASTRAN) program available at UCLA was selected. Use of this program

via the network was planned in stages. In the first stage, the user at ECOM submits punched card input in remote job entry mode. He then receives output via the network suitable for either hard copy on a line printer or viewing on a CRT display in alphanumeric mode. In the second stage, the user manipulates a graphic image of his stress analysis problem, which is then encoded for him by the Varian 620 in terms of NASTRAN source data and is automatically transmitted via the network to the remote computer. In the third stage, the designer is able to view the output graphically, including appropriate plots and tabulated data.

A copy of the NASTRAN package intended to run under OS/360 was kindly provided by NASA AMES Research Center, Moffett Field, California. The UCLA IBM 360/91 was selected as the host computer for the experiment and the NASTRAN package was transmitted via magnetic tape to NBS and then to UCLA.

Figure 1 shows the experimental configuration, in which the node labelled TENEX is at Bolt, Beranek, and Newman. TENEX is the name of the operating system at BBN used to support this configuration.

Figure 2 shows the eventual configuration planned for FY 1973. The BBN computer can be bypassed after the appropriate protocol can be satisfied within the PDP-11 as will be seen below. This changed configuration should greatly increase the reliability of the link to the remote computer facility.

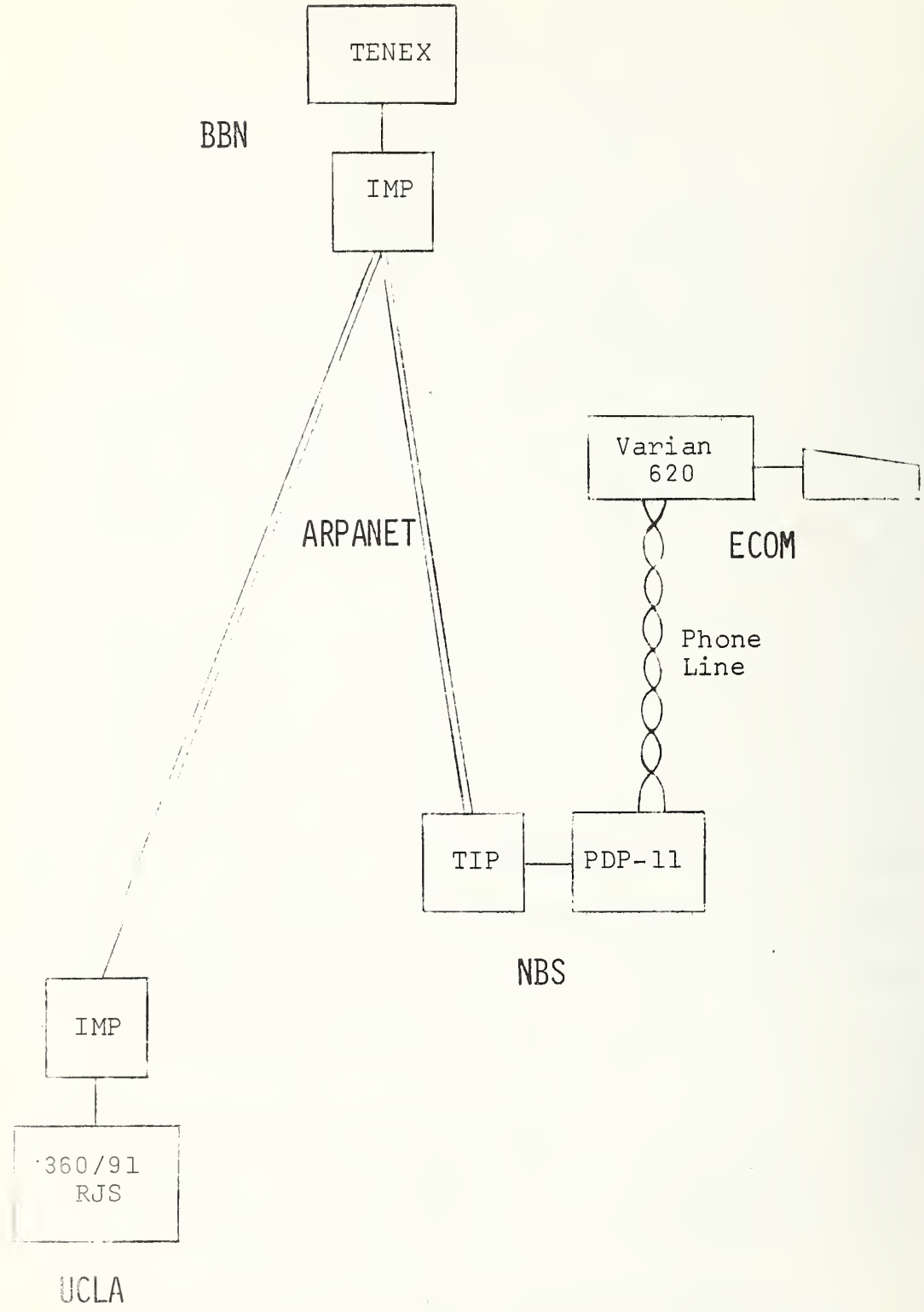


Fig. 1 Interim Configuration

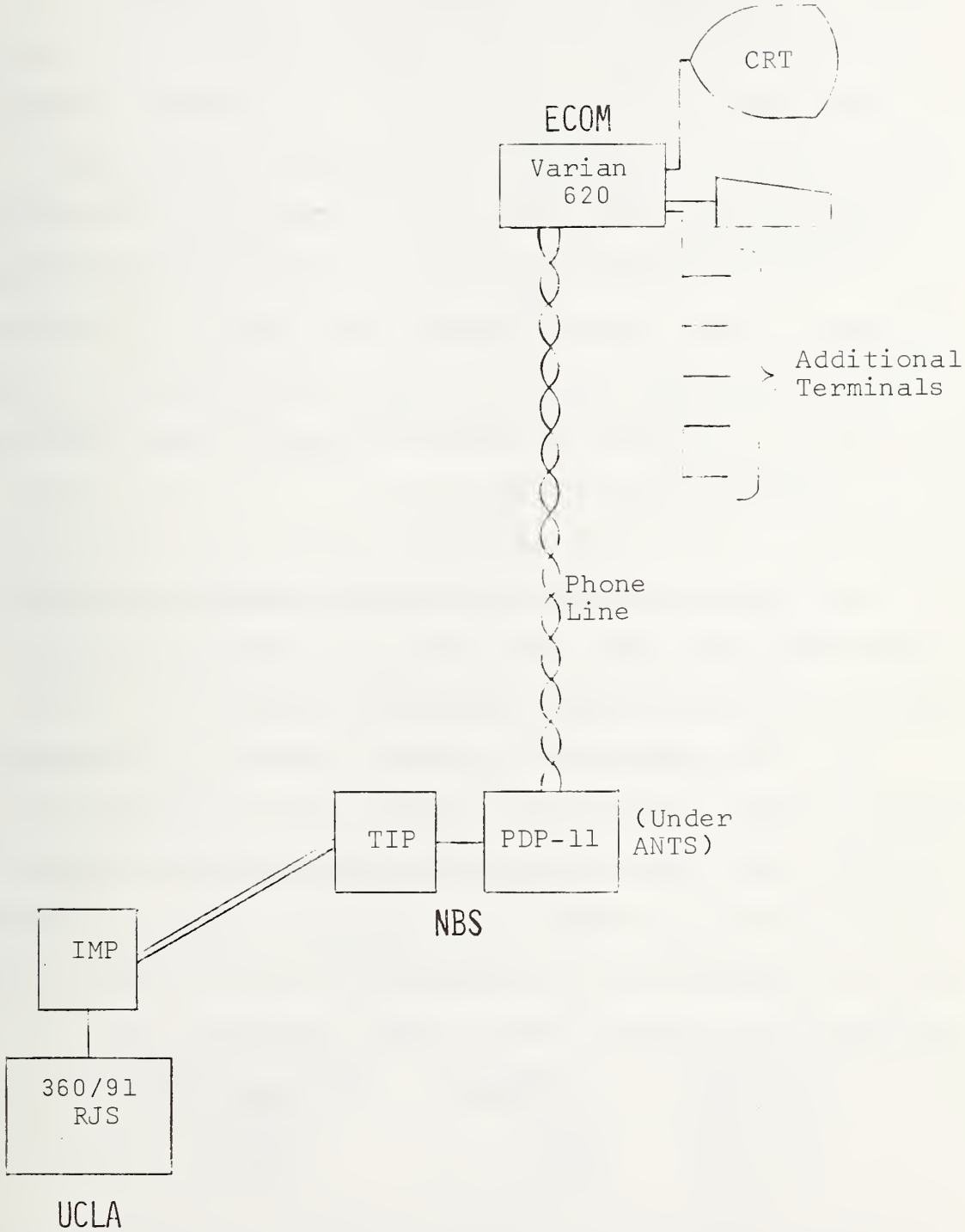


Fig. 2 Eventual Configuration

The change to the eventual configuration will require either the delivery of software from the University of Illinois or the availability of additional core which is now on order for the NBS PDP-11. It will also require stability of the UCLA remote job entry protocol in the network. There are now plans to implement a new protocol, a so-called "standard" remote job entry protocol within the ARPA Network. It is not clear whether the PDP-11 can support both this new standard protocol and the present UCLA protocol. In addition, a variation of one or more of these protocols may be developed in support of the AMC ARPA Network usage to interconnect Ft. Belvoir and Aberdeen facilities.

2.3.3 Reliability

Data obtained by BBN on the ARPA Network [3] host "up times" indicates that, during the period January to June 1972, both UCLA and BBN averaged 80% up-time.

The ARPA communications network itself is considerably more reliable, but software problems were encountered with the TIP. Some bugs remain in the BBN-provided TIP program as of this writing which have an adverage effect on communications reliability. The communication path for the interim configuration involves the following computers:

Location	Computer*	Est. Up Time
(1) ECOM	Varian 620	(80% ?)
(2) NBS	PDP-11	(80% ?)
(3) BBN	PDP-10	(80% ?)
(4) UCLA	IBM 360/91	(80% ?)

*Interface Message Processors and Terminal Interface Message Processors are not shown; their reliabilities are considerably higher.

The figures in parentheses are expected reliability figures for operations during the next few months. Assuming perfect performance for the ARPA network (contrary to our experience) an overall probability for successful job submission to UCLA can be estimated at $(0.8)^4 = 0.41$. Not reflected in this figure is the fact that, particularly for BBN, the ups and downs come at frequent intervals, often without warning, and the destructiveness of a crash, particularly during a remote job entry run can be considerable.

More interesting than the percentage "up time", measured essentially instantaneously, would be data on the time between failures for host systems and for the Net itself. It is the expected up time which determines how likely it is that a terminal session of a given length will be successful. Since turn-around times for NASTRAN runs may amount to hours, it is highly likely that a system averaging hundreds of crashes in a month will prevent successful job completion.

Adequate statistics of this sort are unavailable, except for the knowledge that a figure of perhaps 100 failures per month appears to be typical for BBN. Spread over prime time, this would lead to a typical mean time between failures (mtbf) of about two hours. Much depends of course on how these failures are distributed, and such information remains unknown at this writing.

Much also depends upon the severity of a failure. An automaton is not so flexible as to deal properly with situations such as an operator's message saying: "Please sign off and log back on in 5 minutes". This temporary stoppage is not likely to be serious to a human user, but it would be unmanageable to our automaton. Crashes of any sort then must be considered significant.

Some conjecture can be made about the effect of coupling several systems, each with its own mean time between failures, making a few assumptions about the distribution of times between failures. Suppose systems 1 and 2 are characterized by distributions $N_1(t)$ and $N_2(t)$, where $N_i(t)$ is the probability that system i will fail at a time t measured from its last failure. Each system is characterized by a probability $F_i(t)$ that it will fail at or before time t,

$$F_i(t) = \int_o^t N_i(t')dt'$$

Conversely, we would expect system i to operate without failure at least for time t with probability $P_i(t)$, where

$$P_i(t) = 1 - F_i(t)$$

If systems 1 and 2 are connected, the probability P(t) that <u>both</u> remain up for time t is, assuming 1 and 2 to be independent:

$$P(t) = P_1(t)\, P_2(t),$$
$$= [1 - F_1(t)][1 - F_2(t)],$$
$$= [\int_t^\infty N_1(t')\, dt'][\int_t^\infty N_2(t')\, dt'].$$

Let us suppose P(t) has associated with it a total system distribution of times between failures, N(t), such that

$$P(t) = \int_t^\infty N(t')\, dt'.$$

Differentiating, we have

$$N(t) = N_1(t) \int_t^\infty N_2(t')dt' + N_2(t) \int_t^\infty N_1(t')dt'$$

If the distributions N_1 and N_2 are exponential, of the form

$$N_i(t) = (1/\lambda_i) \exp(-t/\lambda_i),$$

where λ is the mean time between failures, then the composite distribution, N(t), is of the same form, with

$$\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2} \quad .$$

A pair of statistically independent systems, each with mean times to failure of two hours would together appear as a single system with a mean time to failure of one hour; four systems would present a mean of one-half hour; and so forth. The exponential distribution is an excellent model for describing short, uniformly distributed interruptions in a telephone line, radio reception, etc. Needless to say, a periodic polling of a noisy telephone line, in which only a short contact was made (limited sampling), would not permit meaningful measurement of λ. Moreover merely reporting the number of times such polling uncovered a failure is insufficient to describe the statistical mechanism.

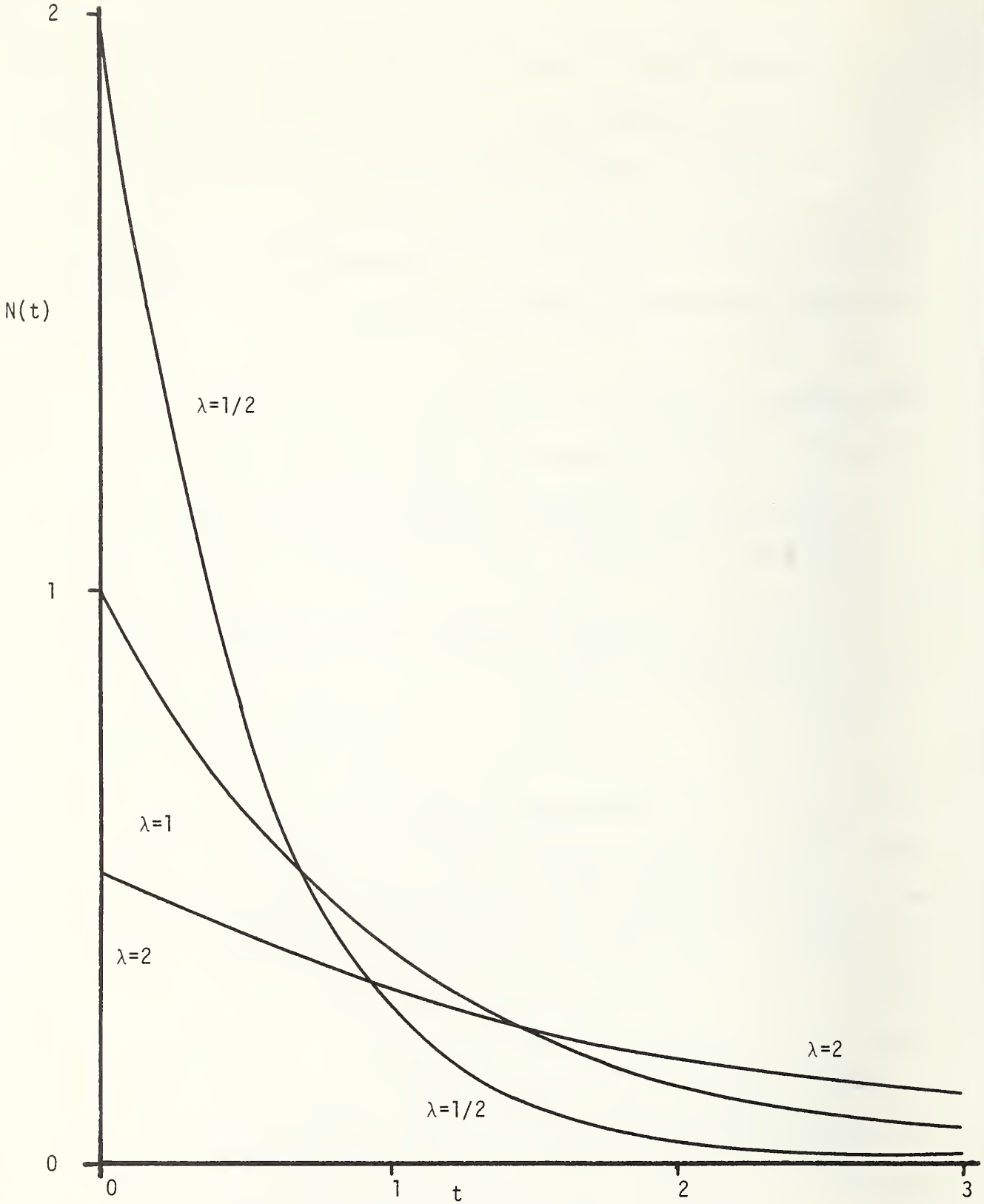


Fig. 3. Probability distributions for systems characterized by mean times between failures of 1/2, 1, and 2 hours. Systems are assumed to have exponential distribution functions of the form $N(t) = (1/\lambda) \exp(-t/\lambda)$.

Clearly, the network and its hosts should be monitored for the acquisition of mtbf data, so that estimates can be confidently made for given combinations.

2.3.4 Other Networking Challenges

Another aspect of the networking situation which deserves mention is the frequent unavailability of relevant documentation. For example, it is usually impossible to obtain DEC system documentation from a TENEX host (requestors are enjoined to write to the manufacturer). Many experimental systems (e.g.: UCLA's Remote Job Entry System) are incompletely documented, and this adds to the frustration of users and system developers.

A related problem is the difficulty encountered when a remote user tries to gain access to a system used to serve the needs of a rather tightly-knit user community. At UCLA, a misunderstanding over the transmittal of an application form for funding delayed the assignment of a chargeable account number for two months. A local user would not have had to use the form, nor would he have to telephone long distance several times coast-to-coast to clear up the matter. The problems of the remote user in general will be made the subject of Appendix A of this report.

Some observations from the implementation of the interim configuration underscored the difficulty of emulating a human user on an interactive system. A related matter is the emulation of a "batch" user of NASTRAN.

A factor that does not augur well for the intended use of NASTRAN is that both the NASTRAN program and OS/360 are somewhat verbose. Both presuppose the user has a line printer or a similar bulk printing device. The available version of NASTRAN provides two copies of the NASA emblem; this is perhaps a forgivable extravagance when contrasted to the total cost of a NASTRAN run, but it is an annoyance to the interactive remote user. UCLA's output also comes with window dressing; the job number is displayed in large block letters. This of course has utility to a busy operator sorting line printer output, but it adds overhead to data transmission.

The process of drawing a connected network of structural members is quite similar to the drawing of an electrical network. The graphical input program should allow for constraint satisfaction by requiring alignment of several points of connection for each member. These "nodes" are required to be numbered and referenced by number in the NASTRAN bulk data input. In general, structures will be three-dimensional; the graphics program must be so oriented. It should allow the user to rotate the picture, or flip it about coordinate axes. It should be possible for a structural member to be called from a list, stretched and scaled to desired dimensions, and attached one point at a time to the other members. Node numbering (in a way so as to minimize the bandwidth of the stress matrix) could be done automatically. The program

should be able to compile the graphical data structure into NASTRAN bulk data statements. Loading of the structure might be handled by requiring the user to apply force vectors to his picture.

For static loads, a data structure similar to the one used at NBS for the thermal design application completed in FY 1971 should be adequate.

2.3.5 Planned Changes in Configuration

Reliability may not always present serious problems, since host facilities are progressing toward more stable and dependable performance. Fig. 4 seems to indicate this trend, and appears to justify optimism in this respect. Careful scheduling will also improve the ECOM-NBS link, and a more operational stance on the part of the ARPANET would eliminate any possible complaint in that quarter.

It is anticipated that certain difficulties may be encountered in graphical translation and the automaton NASTRAN "user". The automaton approach, while it appears workable, is susceptible to several disadvantages:

(1) It will under-utilize the resources of a program the size and complexity of NASTRAN.

(2) Extra processing required to translate a graphical data structure into NASTRAN source data, and the reverse, introduces inefficiency.

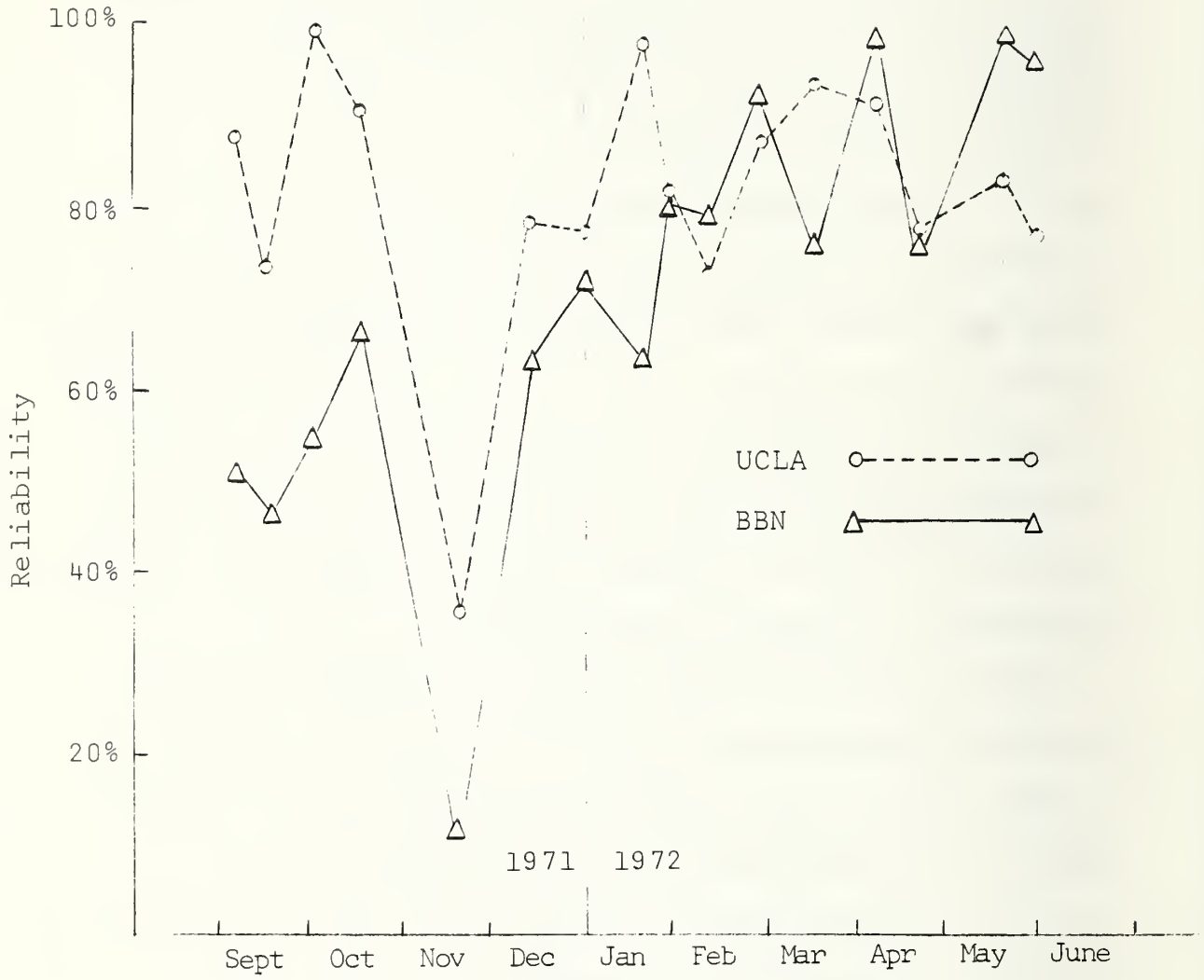


Fig. 4 Reliability of UCLA and BBN Host Systems during FY 1972

(3) There will always be a reliability question, due to the imperfect translation capabilities an automaton may have, and due to updating of NASTRAN and/or OS/360 that may change an output sequence relied upon to ue the automaton.

No doubt there will be pressure to rewrite portions of the CAD-E system as a single entity, though perhaps continuing to execute on more than one processor, including those in a remotely accessible network; there should also be pressure to reduce the number of communication links in the process. It is certain, however, that the sharing of resources made possible through the network will provide earlier results than a completely independent approach, and will place the facilities of a powerful design system in the hands of remote users.

3. CONCLUSIONS AND PLANS

A general test bed network configuration has been implemented during FY 1972. Many things have been learned, some of which are documented in this report, concerning the practical problems involved using computer networks. A working link has been established as described in Figure 1 and is being used in support of ECOM on a regular basis. This link is being evaluated and is scheduled for improvement as the various facilities are delivered to NBS and elsewhere as required in the network.

Continued interaction between the staffs of ECOM and NBS will lead to simplified and more useful protocols for interconnecting design terminals with remote computer services. It will also lead early in FY 1973 to the implementation of performance measurement tools within ECOM and network supported configurations.

Early effort at NBS during FY 1973 will be aimed at summarizing the overall year's study of performance criteria for interactive graphics systems. At the same time a detailed plan for instrumentation of the ECOM design terminal, and of the link from that terminal through the ARPA Network to the IBM 360/91 and/or other host computers will be prepared. This test bed is expected to be a fertile ground for examining the problems of communications protocols, communications reliability, communications flexibility, and in general all of those consid-

derations important to successfully providing substantial computer service through a computer network to a point of need, namely the design terminal in the design laboratory.

References

1. M.D. Abrams, H. Kawai, T.N. Pyke, Jr., "Performance Measurement of Remote Access Computer Systems," NBS Report No. 10381 (1970).

2. T.N. Pyke, Jr., J.A. Hudson, S. Treu, "Performance Measurement of Interactive Graphics Systems in Support of Computer Aided Design and Engineering," NBS Report No. 10451, June 1971.

3. L.G. Roberts, B.D. Wessler, "Computer Network Development to Achieve Resource Sharing," SJCC 1970, pp. 543-549.

4. R.H. MacNeal (ed.), NASTRAN Theoretical Manual, NASA SP 221 (1970), available from COSMIC, U. of Georgia, Athens, Ga.

5. C.W. McCormick (ed.), NASTRAN User's Guide, NASA SP 222 (1970), available from COSMIC, U. of Georgia, Athens, Ga.

6. BBN Network Summaries (Communications to Dr. L.G. Roberts) January-June 1972.

APPENDIX A

RENDERING SERVICE TO THE REMOTE COMPUTER USER

Experience gained as on-site, local, and remote users of university and commercial computer systems has provided insight into various problems of informing and serving the computer user. The universities have included Massachusetts Institute of Technology, University of Pittsburgh, University of Maryland, and University of California at Los Angeles. Commercial sources have included Bolt, Beranek and Newman, Inc.; Dialcom; and General Services Administration Time Sharing. Computers have included Univac 1108, GE 440, Multics, PDP-10, Tenex, IBM/360, and XDS 940. Access has been via the local public switched network, the local switched network plus private connections to remote sites, the Federal Telephone System, and the ARPANET.

Many of the problem areas have been identified by all the servers. Some do not exist everywhere; some exist but have not yet been identified, much less solved. This part of the report serves primarily to identify present and potential problems, and secondly to propose some solutions.

The material in this Appendix is organized under the following headings:

1. Advent of Remote Users
2. Classification of User Communities
3. Problem Definition
4. Information Classification
5. Administrative Policy Relating to Financial Arrangements
6. Information Dissemination
    - 6.1 Documentation
        - 6.1.1 Function to be Served
        - 6.1.2 Methodology
        - 6.1.3 On-line Information
        - 6.1.4 Off-line Information
        - 6.1.5 Published Documentation
    - 6.2 Assistance
7. Technical Capabilities
    - 7.1 Communications
    - 7.2 Supervisor and Security
    - 7.3 File System and Editor
    - 7.4 Languages
    - 7.5 Configuration
8. Operating Procedures
9. Summary

1. Advent of Remote Users

As the community of users of a computer system grows beyond the original local community, the solutions to various managerial problems need to be re-examined. In many cases physical proximity is an implicit component to the solution of problems. When this physical proximity is removed the existing solutions may prove to be inadequate. The purpose of this appendix is to review and tabulate many of the managerial decisions which need to be re-examined when a remote user community is added to a computer system.

2. Classification of User Communities

For the purpose of this discussion, user communities will be divided into three groups. The first group is the on-site users, where on-site may be extended to include those within a psychologically acceptable walking distance. The second group we shall call local, where local is defined to include those within a local telephone calling area and within an psychologically acceptable driving area. The third group is everything that is left, called the remote group; by definition these are the people who are too far away to drive to the computer site and those for whom a telephone call to the site is long distance. In this paper we shall be discussing problems of rendering service to the remote user but a good many of the issues raised also apply to the local user as well.

3. Problem Definition

When computer systems begin to service remote users some of the formal procedures which appeared to be satisfactory for on-site or local users may begin to exhibit defects. It may be that these procedures were already inadequate but the local and on-site communities developed a set of informal procedures to augment the formal ones. It may also be that the established procedures were completely satisfactory for the on-site and local communities but failed when an attempt was made to extend them to the remote community. It is the intent of this paper through a series of questions and discussions to identify the set of procedures which need to be re-examined when remote users are added to a computer system. Hopefully and most likely, not all of these procedural difficulties will exist on every computer installation.

As indicated above, the definition of non-locality is extremely subjective. It is very much influenced by the attitudes of the users themselves and by the operating staff of the computer facility. There are many steps or modes of extending from an on-site operation to one where consideration of remote users needs to be taken. For the purposes of exposition we mention

the following: A batch system with a single I/O dispatch station may expand its services by providing messenger service for pickup and delivery of I/O at remote sites. A batch system may add remote batch capability. Conversational terminals may be provided for a limited geographic area such as a campus or may be made available on the direct-dial network. The "dialing area" for a conversational terminal system may be extended out of the local area by the use of a regional or national network.

4. Information Classification

There are many questions the user will have in coming to see a new computer system. As he gains experience with the system, these questions will be answered and new ones will occur. Since various individuals will use the computer system in different ways, the ordering of questions is not predictable, nor is the level of sophistication. In fact the same individual may ask relatively simple and relatively sophisticiated questions concurrently as his needs for information about the system develop differently in different application areas.

We could say that the answer to all these questions is a management function, and therefore that this document is directed to managerial problems. To do so, however, would be to submerge individual identification into a broad heading. Useful information would be lost in that way. It is observed that the normal organization of computing centers creates areas of administrative responsibility. In this discussion we will therefore try to group together those questions that seem to fall together under each separate administrative responsibility. It is recognized that in many circumstances the demarcation lines may be fuzzy and the particular classification that we choose is therefore to be regarded as arbitrary.

5. Administrative Policy Relating to Financial Arrangements

The first set of questions under this heading has to do with the establishment and the working of accounts. How does a remote user know which administrative forms he must use and how does he acquire these forms? When opening an account what information is required and what restrictions are there as to the classes of users who may be served and/or the rates they may be charged. Are the procedures for processing the forms designed to handle remote users? Are complete mail addresses, titles and telephone numbers provided? In paying for services or supplies what mechanisms are acceptable? If purchase orders are to be used, is there any particular information that should be contained in them? What mechanism exists for continuity between the lapse of one purchase order and the issuance of another one, especially if such lapse is due to administrative restrictions such as fiscal year termination?

Is there clear identification of which services are chargeable against which accounts? For example, if the computer facility operates more than one machine is a separate account necessary for each machine? Can the account that is used for paying for computer time also be used to pay for related supplies such as manuals, tapes, disks, coding forms, etc.? If such charges cannot be made against that account, is it possible to open separate accounts for such supplies or must they be paid for on a piecemeal basis?

Is there an administrative liaison acquainted with remote user problems to whom administrative questions can be addressed? Is this the same person you talk to about opening an account?

Assuming the existence of an account, another set of questions presents itself. How does a remote user determine the status of his account? How does he determine the charges accruing to the account for any individual computer use session? How often are statements issued and when issued how current are they? Assuming the existence of an operating schedule, does that schedule allow for users in different time zones? How is this schedule announced? How closely followed is it? How are remote users notified of changes in the schedule?

6. Information Dissemination

6.1 Documentation

The discussion in this section includes documentation, interactive tutorial programs, on-line help files and all other means employed for communicating information about the computer system. It is recognized that in communication it is important to consider the recipient of the information and that the community of remote users may certainly be assumed to be heterogeneous. Included in this community would be the novice who may be categorized as using his first computer, the beginner who may be using his first remote computer, the experienced programmer who already uses several remote access computer systems and the system programmer who probably wants to modify the basic set of services available.

6.1.1 Function to be Served

All of these people will have questions. Probably they will all start at the same level, but the more advanced will progress further and faster toward a more advanced level of understanding. Their questions may also be answered at many levels and in fact when the question is first asked, the inquirer may not know what level of response he requires.

Program documentation is a form of communication and ought to be considered as such. The essence of communication is sharing. The word "communication" is derived from the past participle of the Latin communicare: "to impart or make common." The information theorists may have done us a disservice by thinking along the lines of communications channels, so that we regard the essence of communications as "sending messages." This has obscured the true essence, namely, that we send messages to share.

Looking at computer system documentation in this way, it seems there is a possessor of something to be shared, called "information". This information about a system (e.g., that it exists, what bugs it is known to have, how to use it, etc.) may exist in the minds of a number of people. Indeed, in most real-world situations, there is probably no one person who knows "everything that is known" about a given computer system.

The kinds of documentation that are needed are as varied as the situations one can conjure up when thinking of sharing. As a result, the extent and degree of formality of documentation may range over a wide spectrum. The difficulty comes when one attempts to determine what kind of documentation is proper in a given situation.

Some of the factors which (should) influence the amount and formality of documentation which is proper in a given situation are:

(1) The temporality of the information--that is, how long will it remain accurate, correct, and/or useful?

(2) The costs associated with inconveniences and calamities which might arise if someone who needs the information can't (or doesn't) get it.

(3) The costs, measured in terms of time and effort, associated with making the information available to those who are likely to need it.

(4) The degree of sophistication of those who share the information. Here it should be remembered that any exchange between two parties rapidly degrades to the level of intelligence of the lesser party.

What we wish to suggest here is that the above four factors are different in the case of remote computer usage as opposed to local usage, and that an analysis of the problems of remote computer usage might well consider these factors. For instance, because the costs associated with calamities may be higher in the case of remote usage, more time and effort to prevent these calamities may be justified in the case of remote users.

6.1.2 Methodology

A constantly reoccuring question is meta-language versus samples. Aside from the linguistic esthetics, the real problem is how to clearly differentiate between those character strings which must be reproduced exactly, and those which change from use to use. Further complicating the question is the existance of optional character strings (i.e., the null string is a special case).

Samples work fine up to some threshold of complexity. This threshold is probably not constant, but rather a function of the writing ability of the documenter. (It is also a function of the reader, but that is a free variable we can not hope to control.) We certainly suggest that samples (alone) be used when they make everything perfectly clear.

When samples are not clear enough, meta-language requires education on the part of reader and writer, and that efficiency is traded for accuracy. One problem in using meta-language is the identification of meta-language constructions (clearly differentiated from those in the language being described). Most commonly this is accomplished by employing characters in the meta-descriptions which are outside the character set for the language being described. For languages whose character sets include only capital letters, meta-language could be written exclusively in lower case letters. Numbers pose a problem which is usually left to context (i.e., it is left unsolved). Another traditional approach has been to select individual or pairs of characters and define them as meta-language delimiters. Conventional use of delimiters identifies all character strings occurring between paired delimiters as being meta-language constructs. It is most convenient if the delimiters are outside the character set, then identification of them is simple. Otherwise, identification of delimiters is itself contextual dependent.

We may begin with the ASCII character set being defined independent of any language. Furthermore, different implementations of the "same" language may employ different subsets of the ASCII character set. It is obvious that we shall have to use the ASCII character set as being "inside". No ASCII character may be assumed to be an intrinsic meta-character or meta-delimiter. Thus we may either define new characters, probably to be used as delimiters, or we can select our delimiters from among the ASCII set and hope to be able to recognize them by context. The commonly used and known delimiters and their applications are:

< > Angle brackets - used to enclose a meta-variable.

[ ] Square brackets - used to enclose a construct which may be optionally omitted.

{ } Brace - used to enclose a set of constructs from which one and only one is to be selected. If one of the constructs is NULL it must be explicitly included. The alternatives are written in a column, or may be separated by a vertical bar "|" meaning logical OR.

$\int_a^b$ Integral - used to enclose a construct which may optionally occur from a to b times.

6.1.3 On-line Information

Progressing in degrees of formality, is there an on-line graffiti file, that is to say a file in which informal comments about the system may be entered? If there is, how is the file maintained, policed, and how does the remote user gain access to it? Also, how is the information in the file dated and how may an infrequent user gain access to so-called ancient material?

Is there an on-line assistance facility? Can the user obtain "help" information about aspects of the system? If he doesn't know what to ask, is there a mechanism for getting him started? Is there a way for the novice to cut off information when it reaches a saturating level of complexity; similarily is there a way for the advanced programmer to skip over the basic introductory material?

Coupled with such on-line help-type sessions is there also an on-line index so that a user may skim through documentation to find the information that he wants? If there is, how does this on-line documentation relate to the normally published documentation? How may the user access this information? What access tools are available for him?

6.1.4 Off-line Information

If there is daily on-line "message of the day" information dissemination, how is this handled at the remote site? Is each individual to get his own copy? Is someone assigned to print out and post a copy of his own? How does the infrequent user obtain back copies of this on-line information?

If there is a local off-line printed news type publication how does the user obtain a copy and subscription to it? What provision is made for copies to multiple users at a given remote site, especially if they come in under the same contract? What provision is made for the remote site to change mailing lists and subject categories for documentation distribution?

6.1.5 Published Documentation

In published documentation we find essentially two classes. One is the set of documents which are produced at and by the facility. Second is the set of documents which are produced elsewhere, by the manufacturer or by other computer facilities from whom systems or subsystems have been borrowed. It is our observation that the remote user is severely burdened if he must go to the originating source for each document. We therefore recommend that all documentation be sold through the same source. But what is that source?

How does the remote user purchase documents? Where does he order them from? How does he order them? How does he pay for them? Are standing orders acceptable? Are subscriptions acceptable for updates, revisions and errata? Are back copies available? What is the delay time between a user's request and the receipt of the documentation?

If the local documentation supplements or contradicts the vendor supplied documentation how does the user find out about these conflicts? What is the mechanism for resolution of such conflicts?

Are documents identified as to the level of sophistication of the user who might employ them? Is there a specific document or set of documents directed to the new user? Does this set of documents describe the capabilities of the computer installation and provide an index to other documentation? How is the availability of documentation announced? How does the user determine which documentation is necessary as opposed to merely available?

6.2 Assistance

Now let us turn to some questions of communications and assistance. Assuming that there exists a mechanism for data communication, what mechanism exists for voice communication? Is WATS, Zenith, Enterprise or the equivalent made available? Is there a single person that remote users contact for assistance? What is his level of technical competence? What is his level of administrative responsibility? What amount of assistance will be given to remote users? Are these remote users to be made aware of the chain of command? When the contact person cannot answer a question or solve a problem, will he follow it up in-house with the appropriate person or will the remote user be referred to the person in-house? To what extent is the remote user permitted or denied access to the technical and administrative staff?

Is there a way of leaving a message which will be answered by the appropriate technical person? Is there a way of communicating between computer users? Is there a separate mechanism for answering easy and hard questions? Is there an on-line conversation assistance service? Is there a way for the remote user to file a formal trouble report?

7. Technical Capabilities

In this section we discuss some of the questions having to do with the actual computer services which are available. The answers to the questions raised herein will occur in the documentation, which has been discussed above.

7.1 Communications

How do you make contact with the computer system? What data communication equipment is acceptable? Are there separate access ports or procedures for different classes of equipment? Are there any hardware optional features which are required for access to the system or which are assumed by the system? What communications rates and codes are supported? Are there any assumptions or provisions concerning terminal characteristics such as lines per page, columns per line, speed and existence of formatting operations such as separate line feed, separate carriage return, combined line feed carriage return, horizontal tab, vertical tab, form feed and backspace? Have any of the non-printing control characters been assigned non-standard functions?

7.2 Supervisor and Security

Once you make contact with the computer system, how do you initiate a session? What terminology is used: session, job, run, conversation, etc.? What is the local name for the operation of identifying yourself and the account to be charged? How do you do it?

What security is there to reduce the likelihood that someone else can identify himself as you and charge to your account or gain access to your files? Are there passwords? If so, how are they established and how may they be changed? Is it possible for a user to change the account number under which he is operating, or to charge some of the charges against an account number other than the one that he signed onto? Are there defaults in the sign-in procedure, and if so what are they?

Concerning communication with the supervisor, is there a control or command language which is used? What is the syntax of this language? What is the minimum capability with this language that is required for the remote user? What is a minimum set that a moderately advanced programmer would need to know?

7.3 File System and Editor

Is there a file system? If it is not called a file system, what is it called? How does it differ from other file systems? What are its salient characteristics? What is the minimum information a remote user needs to know about the file system?

What names are used to identify a collection of information, a subset of that collection or a superset? What restrictions are there on the uses of these sets? What naming conventions exist? Can the same name refer to more than one unit of information? Are the names divided into adjectival qualifiers? If so, what are the separators? What are the parts of the names called? Are there default rules which permit the use of less than the whole name? If so, what are they? How are units of information created and named? How are they modified? In addition to the editors, are there in-line editing features which work even when you are not employing an editor? (For example, deleting a single preceding character, or deleting the entire preceding line.) How are these in-line functions invoked? Can the way they are invoked be changed by the remote user?

7.4 Languages

What languages are available? For each language how is the translator (processor) implemented and what difference does it make to the user? (For example, batch load compiler, incremental compiler, load-and-go, and interpreter.) Can program units written in different languages intercommunicate? Can they be combined to form a program? What combinations are permitted, prohibited, known to work, possible but not guaranteed? Is there compatibility in data structure as well as in subroutine linkage convention? How do the dialects of these languages compare to other dialects and to the standard if one exists? What subsets of other dialects are isomorphic to the subsets of the dialects existing on this computer system.

7.5 Configuration

What devices are available on the computer system? How are they configured and how does the configuration affect the services that are available to the remote user? Can a remote user direct output to a device other than the one that he is using? For example, can a remote user cause material to be printed on the on-site line printer or punched by an on-site punch? Assuming that he can, how does he get his output?

8. Operating Procedures

Is the operating staff aware there are remote users? Are there services available to remote users which are not available to local users, and conversely? Is there a procedure for mailing output and other material to remote users?

How are operating procedure announcements made? Is there a way of obtaining old announcements? When changes are made is the remote user warned in advance? Is there a message which is automatically presented when a session is initiated? How does someone who is not a regular system user keep informed of these messages?

Is there an on-line file system? What limits are imposed on storage? What charges? What backup procedure is maintained? How are backup copies of files loaded? Is there off-line storage on tape or on disks? What is its capacity? How is it addressed? How is it made available? What limitations are imposed? What does it cost? How does a remote user request, renew and release tapes and disks? What procedure is available for him to inquire from the operator about the status of such off-line storage? What procedures are available for transporting or mailing such off-line storage units in addition to other classes of output such as printed paper, punched cards, plotter output, etc.

If multiple classes of service are available such as remote batch, conversational, remote job entry, load-and-go, can these services be intermixed?

9. Summary

The remote user who employs multiple computer systems has enough difficulty in organizing his thoughts and maintaining his competence in the procedures and services which are made available to him from each of the servers. It is incumbent upon the servers to allow him to organize in an optimal manner, and to provide him with sufficient information so that he may effect this organization.

APPENDIX B

ECOM-NBS Synchronous Protocol

1.0 The ASCII character set will be used (see USA Standard X3.4 - 1968).

1.1 The basic unit of information will be an 8-bit byte - ASCII character + parity bit. (Low order bit is transmitted first, parity transmitted last.)

1.2 Synchronous messages will be blocked. At least 4 sync characters (SYN Ø26) will precede each block.

1.3 The block is a line image and may contain a maximum of 132 text characters.

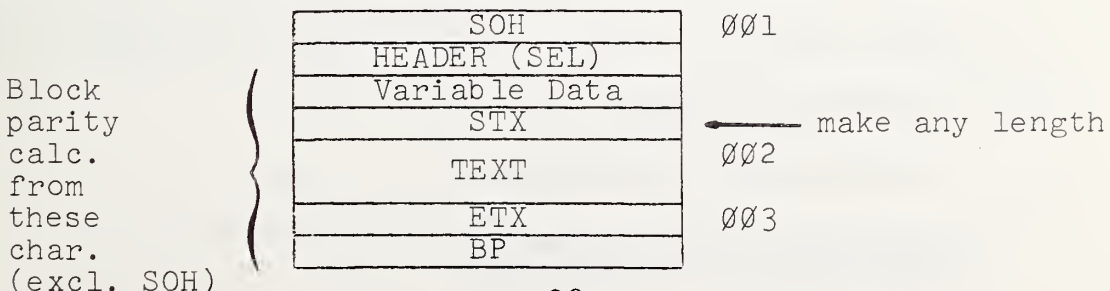
1.4 Text characters within the block (after STX and before ETX) shall have ASCII octal values $\geq 40_8$. (Sync characters, however, may appear anywhere in the block.) (Sync is not included in BP.)

1.5 The parity bit, π, of all characters is normally <u>odd</u> parity; it will temporarily be <u>even</u> parity.

2.0 Several types of blocks will be recognized.

2.1 Message Block

- - - - Format:



2.1.1 Header (SEL char.)

π	0	1	P	d	d	d	d

where π - parity

P - duplicate block protect bit

d - device

not used in initial versions:

- 0000 --- printer
- 0001 --- punch
- 0010 --- peripheral #3
- 0011 --- peripheral #4
- 0100 --- peripheral #5
- 0101 --- peripheral #6

P protects against duplicate block transmission. If rec. station acknowledges a message, and receives another with the same P value it will reject the new transmission (guards against ACK not being seen by sending station). First message must have P = 0.

Peripheral selection allows for forwarding messages to different devices at the receiving station.

2.1.2 STX serves as:

(a) end of header

(b) start of text characters with the next character

2.1.3 ETX ends the text block, and must be followed by BP.

2.1.4 BP (block parity)

Block parity character

π	b	b	b	b	b	b	b

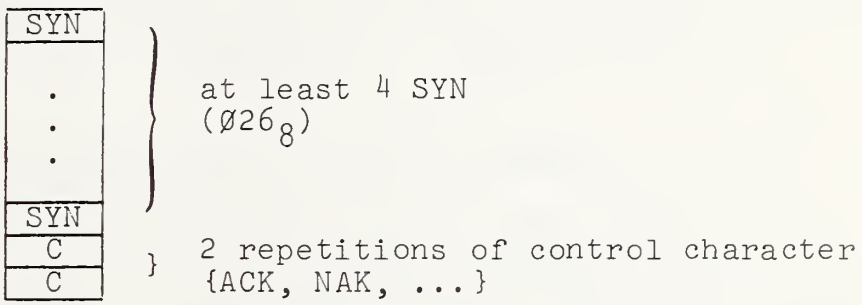
b ... b = logical exclusive OR of all characters in the set.

SEL, STX, ..., ETX

π is computed as though BP were any other character. It is not the exclusive OR of the other parity bits. (Sync characters are not used in forming BP).

2.2 Control Messages ACK, NAK, DC1, BEL, EOT

Message format common to all control messages:



2.2.1 ACK ØØ6

Acknowledges message block just sent; trigger for sender to send next message block. (Next message must have a different duplicate block protect bit in its SEL character.)

2.2.2 NAK Ø25

Requests retransmission of message block just sent.

2.2.3 DC1 Ø21

1st control message received; is equiv. to ACK ... tells Xmitting station to send the first message block. SEL char. must have P = 0 (see para. 2.1.1).

DC1 also sent in response to BEL, at which time the receiving station expects again P = 0 in the SEL.

2.2.4 BEL ØØ7

Used to inform receiving station of delay; receiving station will acknowledge with DC1, and will be prepared for an SEL character with P = 0.

Use in case of card jams, transmission difficulties, etc.

2.2.5 EOT ØØ4

Indicates sending station has finished its transmission. It now becomes the receiving station.

If a receiving station signals EOT instead of ACK or NAK the sending station will stop transmitting and assume receive status.

3.0 Summary of Control Messages ...

3.1 Sending station:

3.1.1 - awaits "DC1" before sending first message block. On receipt of "DC1", sets P bit in SEL character to zero, formats next message from its input device, and transmits it. Sending station awaits ACK or NAK before transmitting next data block.

3.1.2 - on "ACK", complements bit P, formats next message block, and transmits it. On end of file condition, transmits "EOT" control message, and assumes receiver status.

3.1.3 - on "NAK", re-transmits last message block.

3.1.4 - on "EOT", stops transmitting assumes receiver status.

3.1.5 - "BEL" can't be received.

3.1.6 - an unrecognized control message will be handled as a "NAK".

3.1.7 - on transmission difficulties, under operator intervention, sending station will send "BEL" to clear line. (Example: if the RJE station experiences a card jam.)

Receipt of DC1 will resume transmission.

3.2 Receiving Station:

3.2.1 - sends "DC1" when it is ready for the first message block. It then expects a zero P-bit in the SEL character of the first data block.

3.2.2 - on receipt of a data block (any message beginning with "SOH"), checks to see whether P agrees with the expected P. If not, message is ignored, but is acknowledged with "ACK". If so, message is checked for parity and forwarded to its output device. If no errors, sends "ACK" and complements its expected P. If there were errors, it sends "NAK".

3.2.3 - on receipt of "BEL", resets expected P bit to zero, and sends "DC1".

3.2.4 - on receipt of "EOT", assumes transmitter status.

3.2.5 - receipt of "DC1" is meaningless.

3.2.7 - receipt of an unrecognized control message will result in sending "NAK".

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16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This report covers work performed between 1 July 1971 and 30 June 1972 as part of a long-term study of interactive computer-aided techniques. The primary emphasis during this period has been on investigating the feasibility of using computer networks in support of interactive graphics for computer-aided design and engineering. Alternative means for providing remote computer service have been studied. An experimental configuration has been devised taking advantage of the fact that there is located at the National Bureau of Standards a node of the ARPA Computer Network. Arrangements were made via this configuration for users at the Electronics Command to utilize a structural design program, NASTRAN, at a remote computer site. Emphasis has been placed on the evaluation of performance of interactive design techniques using displays supported by local and remote computers in a hierarchical arrangement. A variety of problems are identified which must be considered in order to support interactive graphics via a computer network; these are compounded where the network itself is in an evolving state of development. The report includes an outline of a synchronous communication protocol which was developed for use between ECOM and NBS.

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